

CLAIMS:

1. A communication network (207), comprising:
 - a real clock (100) that determines a pre-determined RTP packet transmission rate for a streaming application, $R_0(t)$, based on encoded content;
 - a real clock (102) (104) having a frequency $f(t)$ that determines a dynamic transmission rate for the streaming application;
 - a streaming server (206) that transmits a plurality of RTP packets at the determined dynamic transmission rate for the streaming application; and
 - a network component (203) that calculates available bandwidth $R_L(t)$ (202) for the streaming application,
 wherein $f(t)$ is dynamically adjusted based on $R_L(t)$ (202) and $R_0(t)$.

2. The communication network (207) of claim 1, wherein the streaming server (206) is a multimedia streaming server.

3. The communication network (207) of claim 1, wherein the frequency $f(t)$ of the real clock (102) (104) is configured as follows

if the real clock (100) is assumed to have a frequency $f(t) = 1$ and T is a time period in which both the real clock (100) and the real clock (102) (104) advance the same distance in time space, that is

$$T = \int_0^{\tau} f(t) dt$$

then

$$f(t) = \begin{cases} R_L(t) / R_0(t) & \text{when } t \leq \tau \\ 0 & \text{when } t > \tau \end{cases}$$

where

τ is determined by $T = \int_0^{\tau} f(t) dt$ and

$R_0(t)$ is a pre-determined RTP packet rate based on content,
wherein, after every T time the real clock (100) and the real clock (102) (104) re-synchronize.

4. The communication network (207) of claim 3, wherein $R_L(t)$ is measured by one of a network interface driver at the streaming server (206), a set of one or more dedicated network components (203) residing in the network (207), and a set of one or more dedicated components at a receiver.
5. The communication network (207) of claim 4, wherein the network (207) is a wireless network and the set of one or more dedicated components at the receiver is a monitor placed into the wireless network driver such that the driver measures $R_L(t)$ (202) and sends the measured $R_L(t)$ (202) to the streaming server (206).
6. An apparatus for dynamically adjusting the transmission rate over a network (207) of a streaming server (206), comprising:
 - a real clock (100) that determines a pre-determined RTP packet transmission rate for a streaming application, $R_0(t)$, based on encoded content;
 - a real clock (102) (104) having a frequency $f(t)$ that determines a dynamic transmission rate for the streaming application; and
 - a network component (203) that calculates available bandwidth $R_L(t)$ (202) for the streaming application,
 wherein $f(t)$ is dynamically adjusted based on $R_L(t)$ (202) and $f(t)$ (302).

7. The apparatus of claim 6, wherein the streaming server (206) is a multimedia streaming server.

8. The apparatus of claim 6, wherein the frequency $f(t)$ of the real clock (102) (104) is configured as follows

if the real clock (100) is assumed to have a frequency $f(t) = 1$ and T is a time period in which both the real clock (100) and the real clock (102) (104) advance the same distance in time space, that is

$$T = \int_0^{\tau} f(t) dt$$

then

$$f(t) = \begin{cases} R_L(t) / R_0(t) & \text{when } t \leq \tau \\ 0 & \text{when } t > \tau \end{cases}$$

where

$$\tau \text{ is determined by } T = \int_0^{\tau} f(t) dt \quad \text{and}$$

$R_0(t)$ is a pre-determined RTP packet rate based on content,

wherein, after every T time the real clock (100) and the real clock (102) (104) re-synchronize.

9. The apparatus of claim 8, wherein $R_L(t)$ is measured by one of a network interface driver at the streaming server (206), a set of one or more dedicated network components (203) residing in the network (207), and a set of one or more dedicated components at a receiver.

10. The apparatus of claim 9, wherein the network (207) is a wireless network (207) and the set of one or more dedicated components at the receiver is a monitor placed into the

wireless network driver such that the driver measures $R_L(t)$ (202) and sends the measured $R_L(t)$ (202) to the streaming server (206).

11. A real clock (102) (104) for enabling a streaming server (206) to perform dynamic transmission rate adaptation, comprising:

a real clock (100) that determines a pre-determined RTP packet transmission rate for a streaming application, $R_0(t)$, based on encoded content;

means for dynamically setting the frequency $f(t)$ of the real clock (102) (104) that determines the rate of RTP packet transmission for the streaming application; and

a network component (203) that calculates available bandwidth $R_L(t)$ (202) for the streaming application,

wherein $f(t)$ (302) is dynamically adjusted based on $R_L(t)$ (202) and $R_0(t)$.

12. The real clock (102) (104) of claim 11, wherein the streaming server (206) is a multimedia streaming server.

13. The real clock (102) (104) of claim 11, wherein the means for determining the frequency $f(t)$ of the real clock (102) (104) is a module that configures the frequency of $f(t)$ as follows

if the real clock (100) is assumed to have a frequency $f(t) = 1$ and T is a time period in which both the real clock (100) and the real clock (102) (104) advance the same distance in time space, that is

$$T = \int_0^T f(t) dt$$

then

$$f(t) = \begin{cases} R_L(t)/R_0(t) & \text{when } t \leq \tau \\ 0 & \text{when } t > \tau \end{cases}$$

where

$$\tau \text{ is determined by } T = \int_0^{\tau} f(t) dt \quad \text{and}$$

$R_0(t)$ is a pre-determined RTP packet rate based on content,

wherein, after every T time the real clock (100) and the real clock (102) (104) re-synchronize.

14. The real clock (102) (104) of claim 11, wherein $R_L(t)$ is measured by one of a network interface driver at the server, a set of one or more dedicated network components (203) residing in the network (207), and a set of one or more dedicated components at a receiver, and that calculates available bandwidth for the streaming application.

15. The real clock (102) (104) of claim 11, wherein the network (207) is a wireless network (207) and the set of one or more dedicated components at the receiver is a monitor placed into the wireless network driver such that the driver measures $R_L(t)$ (202) and sends the measured $R_L(t)$ (202) to the streaming server (206).

16. An operating system kernel function at an application layer (300) of a protocol that implements the real clock (102) (104) of claim 13, wherein, the function interacts with a lower layer (301) of the protocol to return the virtual frequency $f(t)$ (302).

17. A method for implementing a real clock (102) (104) for enabling a streaming server (206) to perform dynamic transmission rate adaptation for RTP packet transmission over a network (207), comprising the steps of:

providing a real clock (100) that determines a pre-determined RTP packet transmission rate for a streaming application, $R_0(t)$, based on encoded content;

dynamically configuring the frequency $f(t)$ of the real clock (102) (104) that determines the rate of RTP packet transmission for a streaming application; and

monitoring the available bandwidth $R_L(t)$ (202) for the streaming application, dynamically adjusting $f(t)$ (302) is based on $R_L(t)$ (202) and $R_0(t)$.

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18. The method of claim 17, wherein the configuring step further comprises the steps of

a. if the real clock (100) is assumed to have a frequency $f(t) = 1$ and T is a time period in which both the real clock (100) and the real clock (102) (104) advance the same distance in time space, that is

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$$T = \int_0^{\tau} f(t) dt$$

then calculating

$$f(t) = \begin{cases} R_L(t) / R_0(t) & \text{when } t \leq \tau \\ 0 & \text{when } t > \tau \end{cases}$$

where

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$$\tau \text{ is determined by } T = \int_0^{\tau} f(t) dt \quad \text{and}$$

$R_0(t)$ is a pre-determined RTP packet rate based on content,

b. after every T time, re-synchronizing the real clock (100) and the real clock (102) (104).

19. The method of claim 18, further comprising the step of:

5 measuring $R_L(t)$ by one of a network interface driver at the server, a set of one or more dedicated network components (203) residing in the network (207), and a set of one or more dedicated components at a receiver, and that calculates available bandwidth for the streaming application.

10 20. The method of claim 18, wherein

the network (207) is a wireless network (207);

the set of one or more dedicated components at the receiver is a monitor placed into the wireless network driver;

the monitoring step further comprises the steps

15 c. measuring $R_L(t)$ (202) by the monitor $R_L(t)$ (202); and

d. sending the measured $R_L(t)$ (202) to the streaming server (206).

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